ElectriSims

a comprehensive detailed simulation of the electric power industry

"The electric power industry is in the midst of evolutionary change. The reliability events during the summer of 1999 (i.e., outages in New York City, Long Island, New Jersey, the Delmarva [Delaware-Maryland-Virginia] Peninsula, the South-Central States, and Chicago and nonoutage power disturbances in New England and the Mid-Atlantic area) demonstrate that the necessary operating practices, regulatory policies, and technological tools for dealing with the changes are not yet in place to assure an acceptable level of reliability."

—DOE Power Outage Study Team (POST) Report 1/2000

Changes in US energy policy have provided the background against which more open, competitive electric markets could develop. State utility regulatory authorities are mandating, through legislation and regulation, changes to the old system in which a single utility had control over nearly every element of the infrastructure within a specific geographic area, usually a state's boundaries. With restructuring, regulated utilities are divesting their generation assets to new entities that operate in a more open, competitive environment. In many states, formerly regulated utilities owning transmission facilities surrender control of these facilities to stakeholder bodies called Independent System Operators. Distribution systems are typically retained by their former monopoly owners and are subject to a new performance-based regulatory regime. The many independent agents that will influence operation and reliability of the infrastructure form a complex system of staggering proportions. New owners and operators will make independent decisions governing up to 17,000 separate generating units; up to 140,000 transmission lines; and up to 100,000 substations. Fifty-eight independent jurisdictions (48 state governments and 9 National Electric Reliability Regions) make rules for parts of the grid; and 130,000,000 end-use consumers will make individual purchasing choices when retail markets for electricity become institutionalized. And these new marketplace dynamics must be carried out using the same physical infrastructure with all its engineering limitations. Implementing new policies and system control strategies and technologies without first examining intended consequences is too risky, especially given the complexity of the system. For example, much of the system's existing reliability stems from deliberate overcapacity in generation and transmission facilities. But this overcapacity may be threatened by marketplace competition where service providers are motivated to reduce costs. And as no one entity is required to generate enough power to meet demand, providers may withhold generation as part of a strategy to maximize profits. New mechanisms will be required to meet reliability requirements of end users and, simultaneously, the engineering and physics requirements of the

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Applications

- **Assess security and reliability of the nation's electricity infrastructure**
- **Analyze the effects of new policies and regulations**
- **Evaluate new network control technologies**
- **Test and calibrate less comprehensive software tools used by individual operators on affordable computer platforms**
- **Resolve disputes over market practices**
- **Provide a user facility for operating utilities, power producers, system operators, power exchanges, and major consumers**

infrastructure. This new environment requires novel analysis and control tools to maintain the level of reliability that consumers expect and that is so important to national stability. Large-scale computer simulation is the best way to predict the outcome of infrastructure changes and market policies before their implementation. Los Alamos National Laboratory is developing a simulation tool that can manage such an immense task—ElectriSims.

Los Alamos National Laboratory is one of three ASCI supercomputing centers.

ElectriSims is a comprehensive, detailed simulation of the electric power infrastructure—comprehensive enough to model the entire North American continent yet detailed enough to represent every element of the infrastructure down to individual generators, transmission lines, control elements, and consumers. Most important, however, is that ElectriSims does what no other simulation tool can do by going beyond the well-defined physical system to include the myriad regulatory, financial, and human behavioral market factors that are less well-defined but that drive infrastructure dynamics. Until recently, a simulation of this scale was computationally impossible, but Los Alamos now has the expertise and the hardware to make ElectriSims a reality.

The Department of Energy's Accelerated Strategic Computing Initiative (ASCI) has designated Los Alamos as the sole site for a 30-teraflop computing capability in 2001. In addition to housing unsurpassed computer hardware, Los Alamos has expertise and experience in developing finite event simulations for the Departments of Defense and Transportation and other sponsors. Among these simulations is TRANSIMS which can model all the interacting elements of the transportation infrastructure down to the level of the individual traveler. TRANSIMS, which has been successfully demonstrated in actual metropolitan scenarios, has taught Los Alamos researchers the important method of developing synthetic household populations. The synthetic data, which are derived from real census data without using actual confidential census information, provide all the necessary variations and properties to support simulations. The expertise derived from TRANSIMS is directly applicable to ElectriSims.

Los Alamos has also augmented its own expertise by collaborating with the Electric Power Research Institute (EPRI), the Energy Systems Research Center at the University of Texas at Arlington, and the California Independent System Operator (CAL-ISO). These collaborations have provided important computer code, experience in the computational complexity of executing various algorithms in retail electricity markets, and an understanding of the complex issues that have already arisen in a state that has begun to deregulate its electric power industry.

Just as CAL-ISO is charged with overseeing California's deregulated electricity infrastructure—including market dynamics and system operation, reliability, and security—a similar entity is needed to oversee the nation's entire, interconnected power grid to ensure stability. The Department of Energy is responsible for reducing vulnerabilities within the US electrical infrastructure, but doing so requires first knowing exactly what those changing vulnerabilities are. Support for ElectriSims development at Los Alamos will ensure that a method exists for predicting, and thereby preventing, problems before they compromise the integrity of the US electricity infrastructure.

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